

# **ARTIFICIAL INTELLIGENCE TOOLKIT TO ENHANCE UNDERSTANDING AND KNOWLEDGE**

Final Report

JPL Task 1029

Dr. Ayanna Howard, Mobility Systems Concept Development Section (348)

## **A. OBJECTIVES**

The Artificial Intelligence Toolkit (AI Toolkit) is a software package designed to train future scientists and engineers in soft-computing methods that are applied to current robotic research efforts. Three artificial-intelligence techniques are introduced in the software toolkit, namely fuzzy logic, neural networks, and genetic algorithms. The infusion of these multiple technologies have been used in various aspects of the space robotics research arena – from rover navigation on rough terrain such as is found on Mars [1] to safely landing a robotic spacecraft on a previously unknown planetary surface [2].

## **B. PROGRESS AND RESULTS**

The use of artificial intelligence (AI) technologies, such as neural networks, genetic algorithms, and fuzzy logic, has seen an increase of use in real-world systems over the past few years. Yet, there is still a hesitation in space systems to incorporate aspects of this technology in mission-critical applications. There is still a large disconnect between research and mission-based applications when it comes to embracing the use of AI techniques. However, there is no reason why this gap cannot be bridged. By creating an environment of understanding in which engineers begin to appreciate the underlying benefits of AI techniques and other researchers can also be trained in its use, the infusion of artificial-intelligence methodologies into real-world space systems will be enhanced. As AI can only enhance the capabilities of future missions, enabling tasks such as the autonomous search for life, knowledge-driven data analysis and acquisition, and long-range rover traversal, the use of AI becomes of direct benefit to NASA-JPL.

To enhance learning and promote communication, we have developed an interactive AI toolkit. The core elements of this research that have been developed are:

- Comprehensible training module for current and future researchers and engineers on three AI technologies, namely: genetic algorithms, neural networks and fuzzy-logic technologies.
- Interactive graphical interface for providing hands-on examples of applying AI techniques to real-world research problems.

The three AI methodologies embedded within the toolkit include:

- Fuzzy Logic

- Humans have perfected the ability to function effectively in an always-changing and unknown environment. We can drive a car without having to calculate the exact turn angle to produce a right-hand turn. We can traverse through a crowded conference room without colliding into the person standing in front of us. In essence, we operate throughout our entire lives using inaccurate measurements and imprecise knowledge. Fuzzy logic is a way to embed this type of human behavior into AI systems. By using linguistic terms and conditional statements, fuzzy logic allows a system to solve problems without requiring exact measurements of the input data. For our hands-on application, we show fuzzy logic in use for a robot-navigation system.
- Neural Networks
  - An artificial neural network allows a system to represent arbitrary input-output relationships without being limited to linearity. A feedforward neural network is trained by finding a set of weights that will output a desired output for a given set of training data input. Tasks such as detecting biosignatures using retrieved instrument data, or recognizing scientific targets in visual input data, can easily be solved by a neural network AI system. For our hands-on application, we show neural networks applied to a gender-identification problem.
- Genetic Algorithms
  - Genetic algorithms model the behavior of the evolution process in nature. GAs are an ideal technique to find a solution to any optimization problem. GAs can be used to adaptively evolve software in response to system failure or build the ideal rover-mobility platform. For our hands-on application, we show neural networks applied to a planet-traveling problem.

## **C. SIGNIFICANCE OF RESULTS**

Through the process of knowledge transfer, integration, and presentation, the AI Toolkit represents a method for bringing soft-computing research to the forefront. The toolkit represents an effort to successfully bridge the gap between robotics research and application.

## **D. FINANCIAL STATUS**

The total funding for this effort was \$25,000, all of which has been expended.

## **E. PERSONNEL**

Gene Chalfant (348) assisted in designing the genetic-algorithm tutorial. Eric Rogstad (348) assisted in developing graphics and creating the layout for the genetic-algorithm tutorial and lesson. Beta testing was done by Eric Rogstad (348) and Adrienne Huffman (348).

## **E. PUBLICATIONS**

In submission: A. Howard, E. Graham, “Bridging the Gap between Space Robotics Research and Robotics Education”, Accessible Hands-on AI and Robotics Education Workshop, AAAI Symposium, March 2004.

In addition, two New Technology Reports (NTR) have been submitted and the software is now available through Open Channel Software at

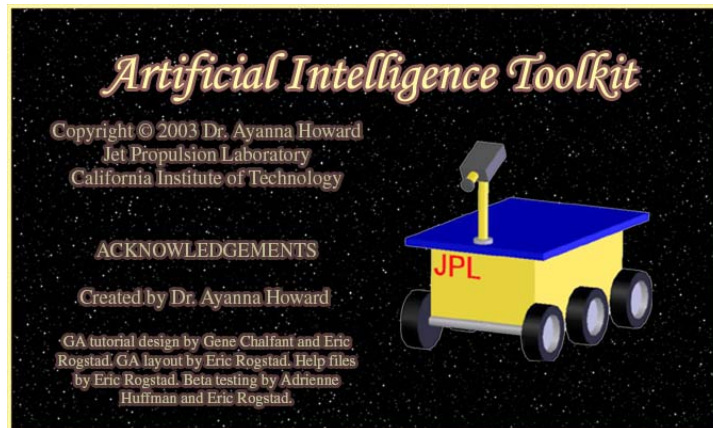
[http://www.openchannelsoftware.com/projects/AI\\_Toolkit](http://www.openchannelsoftware.com/projects/AI_Toolkit)

## **G. REFERENCES**

- [1] E. Tunstel, A. Howard, T. Huntsberger, A. Trebi-Ollenu, J. Dolan, “Applied Soft Computing Strategies for Autonomous Field Robotics,” Fusion of Soft Comput. and Hard Comput. for Autonomous Robotic Sys., Physica-Verlag, 2003.
- [2] Howard, E. Tunstel, “Using Geospatial Information for Autonomous Systems Control,” Frontiers of Geographic Information Processing, Springer, 2004.

## H. APPENDIX

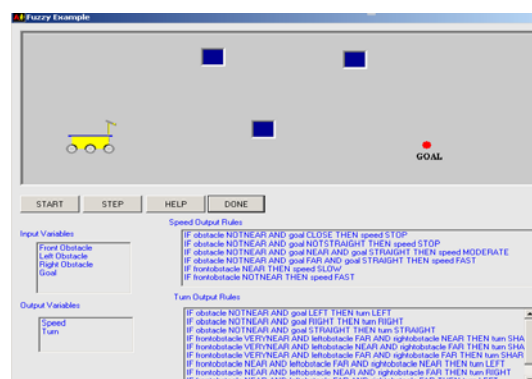
The following images are snapshots from the AI Toolkit.



Introductory screen of the AI Toolkit



Genetic algorithm application for spacecraft planning



Fuzzy logic application for rover navigation